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COAL MINES:
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COAL MINES:

THE CAUSE OF FIXED AIR,

WITH

OBSERVATIONS

ON

TEMPERATURE, DEPTH, AND EFFECTUAL VENTILATION.

By HENRY STIRK.

LONDON:
EFFINGHAM WILSON, ROYAL EXCHANGE.

1885.

PREFACE.

It may be considered presumption in any one to write on a subject which must have occupied the attention of superior minds conversant with the dangers and inconveniences existing in mines for a century or more. But the subject matter is of such paramount importance to miners, proprietors of mines, and to the public, and as we know that some of the great improvements in applying the discoveries of men regarding the laws of the material creation, have been the result of observations as to how those laws act with and upon each other, and feeling that if such laws can be brought into co-operation in mines and other places, a grand object—viz.: to provide a way for the inflammable gas to escape from mines, thereby dispelling the danger of explosions, and rendering the working in mines more healthful—will be attained. These considerations have induced me to lay this work before my countrymen. The method I place before my readers in the following pages will, I hope, be put to the test. I shall wait with deep interest the trial, but without any fear as to the result. Should it be adopted, I strongly advise that *workmen conversant with gas works* be employed to fix the tubes or pipes for carrying away the rarified air, for effectuating perfect ventilation.

Peckham, Surrey.
1885.

IT is an acknowledged truism, "First know the cause and the reason of a disease before you presume to prescribe a remedy."

It may be useful to divide the subject under consideration into propositions, distinct from each other, then offer observations and remarks upon each, and conclude with a statement of the method proposed, drawn from settled laws in the material creation, by way of inference.

In this case then I propose to divide the subject into five propositions. The proposed remedy will follow.

I.

LIGHTING AND VENTILATING COAL MINES NOW IN USE, AND TO DEMONSTRATE THAT SUCH VENTILATION IS A DIRECT INFRACTION OF THE LAWS BEFORE-MENTIONED.

II.

ATMOSPHERIC PRESSURE.

III.

Central Heat considered and proved a fallacy.

IV.

Elasticity of the Atmosphere, and its property to rush from under pressure into freedom.

V.

Heat diffuses itself amongst neighbouring bodies until all arrive at the same degree of temperature. Under this head I propose to account for the formation of Ice.

VI.

Concluding with the Method suggested to Reduce the Temperature in Mines, and to obtain circulation of air or atmospheric fluid throughout all the workings therein. And this method will apply to ventilation generally.

1. *Lighting and ventilating of mines now in use.*

"Ventilation" here intended, is the act of expelling impure air and of dissipating noxious vapours. Before stating the case as to lighting and ventilating coal mines, it may be of use to mention what a well-known writer says upon the subject of ventilation.

"Few persons are aware how very necessary a thorough ventilation is to the preservation of health. We preserve life without food for a considerable time, but keep us without air for a very few minutes and we cease to exist. It is not, however, enough that we have air, we must have *fresh* air; for the principle by which life is supported is taken from the air in the act of breathing. One-fourth only of the atmosphere is capable of supporting life; the remainder serves to dilute the pure vital air and render it more fit to be respired. By the care we take to shut out the external air from our houses we prevent the escape of deteriorated air and condemn ourselves to breathe again and again the same contaminated, unrefreshing atmosphere. Who, that has ever felt the refreshing effects of the morning air, can wonder at the lassitude and disease that follow the continued breathing of the pestiferous atmosphere of crowded or ill ventilated apartments? It is only necessary to observe the countenances of those who inhabit close rooms and houses, the squalid hue of their skins, their sunken eyes and their languid movements, to be sensible of the bad effects of shutting out the external air. Chemistry, however, has furnished the means of purifying the air of chambers in which persons have been confined with contagious diseases" (*infectious*) "or in which bad air is generated in other ways, so as to destroy the noxious or offensive power of the effluvia generated in such situations, and thus preventing its injurious influence. No fumigation will be of any avail in purifying stagnant air, or air that has been breathed till it has been deprived of its vital breath; such air must be driven out, when its place should be immediately supplied with fresh pure atmosphere. The readiest means of changing the air of an apartment is by lighting a fire in it, and then throwing open the doors and windows; this will set the air in motion by establishing a current up the chimney."[1]

If the reader will follow me, I think a much easier and an effectual way of ventilation will be shewn—and that without lighting a fire, viz.: by providing a way for the rarified air to escape.

The following account of "Lighting and Ventilating of Coal Mines" is contained in *The Penny Magazine*, vol. 4:—

"The explosion of inflammable gas or "firedamp" in coal mines which is now even occasionally heard of, used to be much more frequent. It arises from the following circumstances: All coal contains in its natural state while underground a considerable quantity of free uncombined gas which it parts with when exposed to the air, or when it is relieved from great

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(1.) *The Scientific* and Literary Treasury by Samuel Maunder, article *"Veutilation."*

superincumbent pressure. The gas is evolved from the coal in great quantity at the ordinary temperature of the mines, and as there are numerous fissures in the roofs or the "ways" or excavations sometimes extending for miles, they may be regarded as natural gasometers in which the gas accumulates to a highly condensed state; coals lying deep give out more of this gas than those near the surface, because there are openings at the surface by which the latter may escape; whereas in deep mines it cannot have such an outlet, and, therefore, it accumulates there most largely. In working the coal, sometimes the miners cut across one of the fissures or approach so near to it that the intervening rock or shale becomes too weak to resist the elastic force of the condensed gas: it gives way, and the gas rushes out with immense force.

"The gas thus emitted has these precarious qualities, that when kindled as a jet issuing from the coal, it burns with a bright flame like ordinary gas; but when mixed with a proportion of atmospheric air it becomes explosive, and is then highly dangerous. If the proportion of gas to air be more than about one to fourteen, a liability to this explosion ensues: hence the mining engineers endeavour to make such arrangements as may keep below the dangerous ratio. They cannot lessen the quantity of gas issuing from the coal, but they can increase the quantity of fresh air admitted into the mine.

"Large fires are kept in some of the mines constantly burning at the mouth of the ventilating shaft, which shall occasion (or are intended to) a draught sufficient to carry up the foul air, and air pumps are added to quicken the draught. In some cases the gas generated by the coal is so great as to require nearly twenty thousand cubic feet of atmospheric air to be forced into the mine every minute to keep it in a safe working state. Doors are constructed across the various passages, at certain places, with the object of compelling the fresh air which may be forced into the mine from above to follow in a certain track, and to pass through all the passages in succession, clearing out the foul air as it goes. Boys are kept to attend to these doors when a corve or coal tub is about to pass, and to close it immediately afterwards."

One and perhaps the greatest of the formidable obstacles in the way of the advancement of knowledge is the neglect of rudiments or first principles. If foul or impure air, as it is called, be owing to rarification caused by heat to occupy more space than fresh air, it becomes when rarified lighter by many degrees than air not so heated, and if we can give rarified air a way to escape, we shall make room for fresh air to occupy its place, and atmospheric pressure will force it to do so;

hence coal mines, underground railways, and indeed any place or situation containing rarified air, may be rendered free from the incubus by a conduit pipe, hereinafter described, to give the light air a way to rush out into freedom, and allow the fresh air to enter to supply its place. After many years of careful study I arrived at this conclusion, that the present method used in ventilating coal mines, directly impedes ventilation and adds to the danger of explosions, and having arrived at that conclusion, I sent, in the autumn of 1882, to an eminent physician in the North of England, an outline of my reasons for disagreeing with the unscientific way of ventilating coal mines, with suggestions. He most kindly read the inchoate paper which I then sent to him, and returned it with a letter, of which the following is a copy.

Nov. 26th, 1882.

"Dear Sir,

"I have perused all your communications and sent them to Mr. * * * , who says he cannot spare time. Your plan of forcing pure air throughout all the mines is very worthy of serious consideration, being the reversing of the present system of placing a large fire at the bottom of the upcast shaft and sucking the foul gas from the workings and bringing pure air by the downcast shaft.

"This requires no mechanical power, as combustion changes the gaseous elements of both pure and impure air producing in chemical changes. Your plan of forcing air from the surface throughout all the seams and places where men are or have worked is a very right principle, only the expensive engines on the surface and the tubes through thousands of yards and the shafts and passages would require great power and have resistance of extra atmospheric pressure to overcome.

"We have no apparatus here to carry on satisfactorily operations to test the feasibility of your plan. The carburretted hydrogen, chemically produced in the coal strata workings, &c., would require an immense supply of air to decompose and purify its elements, as in a room with fire, gas, and the breath of persons sitting, &c., the pure air of a room is deprived of oxygen, and becomes both offensive and deleterious, and requires more ventilation. The supply of oxygen for the lungs will be deficient.

"You speak of heat and density, but have not fully considered the chemical action and composition of fire damp.

"I wish you every success and adequate remuneration, and shall be glad to hear from you when you publish your views."

The physician's letter gave me encouragement, knowing his great ability and worth, and I determined to examine minutely all the rudiments or the elementary ground, and this brought to my recollection cases which I think confirm the conclusion contained in my outline sent to the learned physician in 1882.

In my deliberation upon the Doctor's letter a state of facts came into my recollection—I did not at the time I witnessed them know the reason of the result I saw—which proves beyond all controversy, that the method hereinafter proposed would have the desired effect, and shews that no machine of any kind, expensive or otherwise, is necessary.

I remembered that in the year 1824, I saw a brass furnace at Skipton, in Craven, constructed by Richard Noble, an iron and brass founder, as follows: he dug a square hole in the floor of the foundry, near the outside wall, of about 5 or 6 feet in depth; at the bottom a space was left to receive the ashes, one foot from the bottom of the furnace a wrought iron grating was fixed to hold the coke, from the grating a flue was carried by a drain cut from the bottom of the brass furnace and thence through the outside wall; at the end of that drain a sheet iron chimney was fixed against the outside wall of the foundry, about fifteen feet high; a fire being lighted in the brass furnace it burnt with a white heat without any force of bellows. The brass was melted in a crucible, a vessel or melting-pot made of clay, and so tempered and baked as to endure the greatest fire. The crucible was placed into the middle of the fire and drawn out with tongs having a circular mouth to fit round the crucible. The reason of the fire burning with such intense heat was the atmospheric pressure on the top of the fire which was left open to receive it, and that air becoming rarified by passing through the fire and having a way to escape, provided as before mentioned, the required effect was produced. The furnace was lined on all sides in the inside with fire bricks, and a wall of some two feet high built also with fire bricks was carried up above the floor of the foundry.

The furnace never smoked or was in the least unpleasant, the flue was placed under the fire and not above it; this (by the way) is suggestive of a plan to dispense with smoky chimneys in dwelling houses. The flue must enter into the chimney from directly under the fire, and not as we have them, above the fire, and the fire-grate must be made of wrought iron.

The fire-places must be constructed as at present, with iron folding-doors placed above the fire—this would facilitate the sweeping of the chimney.

This principle applied to mines, tunnels, underground railways, and all other places requiring ventilation, would produce the like result, namely, perfect ventilation. The tubes mentioned and described in the sixth division may be constructed of light metal, such as sheet iron or tin, which could be removed from coal mines when all the coal was exhausted, so that the cost would be trifling in comparison to the benefit to arise from the application.

The other case I remembered after reading the learned physician's letter will be mentioned when considering the property of the firmament (atmospheric fluid) to carry sound in straight lines.

II. Atmospheric Pressure.

Before attempting to describe how atmospheric pressure acts upon the air in coal mines, it may be well to set down some facts relating to that quality in the air.

The discovery of atmospheric pressure is pointed out by Parke, in his "Chemical Catechism," in an additional note, p. 418. He says, "The rise of water in a pump was formerly attributed to the horror that nature had of a vacuum. This absurd notion was refuted about the middle of the seventeenth century by the following occurrence.

"The Duke of Florence having occasion to raise water to the height of 50 or 60 feet, ordered a common pump to be made for that purpose; but when it was completed the workmen were astonished to find that it would not work.

"The matter was referred to the celebrated Galileo, but he was unable to account for it in any way. All that they were able to determine was that water would not rise in a common pump more than thirty-two to thirty-five feet. The fact remained inexplicable until philosophers caught the idea of atmospheric pressure, since which time the suspension of mercury in the barometer, and water in a pump, have been well understood."

The learned author of the Catechism, at p. 46, gives an account of the first perception, or one of the first, into the fact of atmospheric pressure. He says that "Messrs. Robertson and Sacheroff, who ascended with an air balloon from St. Petersburgh in June, 1804, took some live pigeons with them. At different heights they gave liberty to those birds, who seemed not very willing to accept it. 'The poor animals were so terrified with their situation, that they clung to the boat till forced from it, when it appeared that their fears were not groundless, for, on account of the rarity of the air, their wings were nearly useless, and they fell towards the earth with great rapidity. The second struggled with eagerness to regain the balloon in vain, and the third, thrown out at the greatest elevation, fell towards the earth like a stone, so that they supposed he did not reach the earth alive.' Retrospect vol. I., 94. This relation affords a fresh instance of the harmonies of nature, and of the suitableness of every creature to the medium in which it was designed to live. The density of the air near the surface of the earth, we see, is exactly what was requisite for the feathered race; and the specific gravity of every individual of every species is just sufficient to enable it to occupy that element, and to move within it at all times with ease and safety."

The properties of atmospheric air have been divided into four heads, as Fluidity, Elasticity, Expansibility, and Gravity. It has been considered that, for the present purpose, it may be well to limit ourselves to the three latter properties of the atmospheric air, viz.: Elasticity, Expansibility, and Gravity.

If atmospheric air be compressed into a small compass, it has the property of recovering its former state as soon as the pressure is removed, which is called its Elasticity. The air gun and the forcing pump are constructed upon this principle.

The Expansibility of the air is its property of being rarified by heat, so as to occupy a larger space than it does before the application of heat.

The Gravity or weight of the atmospheric air was, it is thought, the last property discovered. Since the date of the balloon ascent from St. Petersburgh, in 1804, the knowledge of the law of atmospheric pressure has from time to time received advancement.

I do not profess to have discovered any new law or principle regarding atmospheric pressure; what I have done is to study and examine what the best authors within my reach have written upon the subject, and, comparing what I have read with actual observations of my own, I am led to believe that the following pages contain a statement of the cause of coal mine explosions and of the unhealthiness of the occupation of coal miners; and that the system suggested will, on trial, prove to be an effectual remedy. The method of improving the ventilation of mines will apply equally to ventilation generally.

An excellent book was written by the late Dr. Arnott. entitled "Elements of Physics on Natural Philosophy," General and Medical, written for universal use in plain or non-technical language, and containing new disquisitions and practical suggestions, published by Longmans & Co., 1833.

When writing upon atmospheric pressure, vol I., p. 340, Dr. Arnott says—

"PRESSURE IN ALL DIRECTIONS.

"A quantity of air or gas shut up in any vessel, and compressed, is equally affected throughout, and its tendency to escape from the pressure is equal in all directions, as is proved by the force necessary to keep similar valves close wherever placed. Owing to this law, air, when allowed, will always rush from where there is more pressure to where there is less. The actions of the common bellows, and of the animal chest in breathing, blowing, sucking, &c., are so many instances.

"The suddenness with which any compression made on part of a confined aeriform fluid is communicated through the whole is strikingly seen in the simultaneous increase or burst of all the gas lights over an extensive building, or even in a long street, at any instant when the force supplying the gas is augmented."

The Doctor speaks of interesting illustrations of the fluid pressure of air being in all directions, which occur under the next head into which he divides the subject, joined with proofs of the atmospheric pressure being as the depth.

PRESSURE AS THE DEPTH.

On first approaching this subject a person is naturally surprised to hear the depth or height of the atmosphere spoken of as something perfectly ascertained, although nobody could ever have approached the surface to measure it; but science often furnishes means of reaching precise truth in cases where ignorance would not even dream of the possibility of making an approximation. It may facilitate the apprehension of this point, as regards air, to describe first, some parallel cases in which water is concerned.

The bottom of a lake evidently supports all the water in the lake, and each portion bears just the weight of water directly over it; a means then of ascertaining the weight or pressure of any portion of the bottom would tell how much water stood over that portion, and by the known relation of the weight and bulk of water, would also tell the depth at that part. In like manner the ocean of air which surrounds this, our globe, rests with its whole weight upon the surface of the globe and each portion of the surface bears its share. If we ascertain then the pressure of the atmosphere on a given extent of surface, we can find by that how much air is standing directly over the whole.

If a bag holding a cubic foot of air is emptied into the copper ball of an air gun, the ball weighs about an ounce and a quarter more than before. The same volume of water weighs nearly a thousand ounces, so that common air is about a thousand times lighter than water.

Accurate experiments shew that there are nearly fifteen pounds weight of air over every square inch of the earth's surface, producing the same pressure as would be made by a depth of water of thirty-four feet, or by a depth of quicksilver of thirty inches; and from this fact, and the ascertained lightness and elasticity of the air, we know that its depth on earth must be nearly fifty miles, which is about as much in relation to the size of the earth as a tenth of an inch is to a globe one foot in diameter.

The atmospheric pressure is greater the nearer the earth, consequently, that pressure increases in all mines in a ratio measured by the depth—the pressure being equal on all sides of any object; thus, a person walking under an ordinary sized umbrella bears a weight of many tons, but that weight is not felt by reason of the same weight beneath the umbrella meeting the weight on the top of it, but in a coal mine the weight is not so equalized, and hence the greater difficulty in breathing at the bottom of such a mine than is experienced outside the mine in the open air.

The laws of the Creation differ from human laws in that the former are uniform, certain, and infallible, while the latter are not so. We must be careful not to state anything unsupported by authority. Parke says that atmospheric pressure was not known until the beginning of the present century. It appears in a book written by James Ferguson, intituled "Astronomy explained upon Sir Isaac Newton's principles, and made easy to those who have not studied Mathematics." What I now set down from Mr. Ferguson's book is copied from the seventh edition, published in the year 1785. Ferguson died in 1776. It is possible, therefore, that, as the seventh edition was published after its author's death, some other hand may have added the 175th and 176th sections. The truth of the existence of atmospheric pressure is now too well settled to need any further proofs, but I think it right to give the circumstance. It is stated, Ferguson, ss. 175, 176, as follows :—

"The weight of the air at the earth's surface is found by experiments made with the air pump, and also by the quantity of mercury that the atmosphere balances in the barometer, in which, at a mean state, the mercury stands 29½ inches high. And if the tube were a square inch wide, it would at that height contain 29½ cubic inches of mercury, which is just 15 pounds weight; and so much weight of air every square inch of the earth's surface sustains, and every square foot 144 times as much, because it contains 144 square inches.

"Now as the earth's surface contains in round numbers, 200,000,000 square miles, it must contain no less than 5,575,680,000,000,000 square feet, which, being multiplied by 2,160, the number of pounds on each square foot amounts to 12,043,468,800,000,000,000 pounds, for the weight of the whole atmosphere. At this rate, a middle sized man, whose surface is about 15 square feet, is pressed by 32,400 pound weight of air all around; for fluids press equally up and down, and on all sides. But, because this enormous weight is equal on all sides, and counter-balanced by the spring of the air diffused through all parts of our bodies, it is not in the least degree felt by us." s. 176. "Oftentimes the state of the air is such, that we feel ourselves languid and dull; which is commonly thought to be occasioned by the air being foggy and heavy about us. But that the air is then too light, is evident from the mercury sinking in the barometer, at which time it is generally found that the air has not sufficient strength to bear up the vapours which compose the clouds: for, when it is otherwise, the clouds mount high, and the air is more elastic and weighty about us, by which means it balances the internal spring of air within us, braces up our blood vessels and nerves, and makes us brisk and lively."

This feeling of lassitude is experienced on entering into the region of confined, and in consequence, rarified air. The way to remedy this is not to contrive ways to force in fresh air, but to make a way for the confined or rarified air to escape, and the atmospheric pressure will force in fresh air—which may be done easily in the way pointed out in the VIth Division, which I have drawn as an inference from the known laws of the atmosphere, and I have been confirmed therein by men in whom I can fully confide, men who have all their lives been employed in gas works.

If means can be adopted to cause the confined or rarified air, either in a coal mine or in any other place, to rush out into the open air, its effect would be a free draft of fresh air in and throughout the mine or place. And the gas in a coal mine being even lighter than the confined or rarified air in it, that gas would precede the confined or rarified air in rushing out of the mine into freedom.

We may safely conclude that the authors I have consulted and mentioned are quite right. I would add here *some* observations of my own, in all of which I saw instances proving that the laws now under consideration act in unison. Before however stating them I beg to be allowed to premise:

When any one undertakes the study of a science, no matter which, if he fails to become well grounded in the elements, or the A B C of that science, he can never apply what others have discovered to his own observations; and, what is of equal importance, he can never make any one who has not studied that science understand any part of the science on which he is, either writing or speaking.

This was impressed upon my mind in the days of my youth by what once happened at *nisi prius*. On a trial before the first Lord Denman—whose father, Dr. Denman, of Bakewell, in Derbyshire, was, in his day, perhaps, the most, or one of the most, skilful medical practitioners in the kingdom—a young counsel called and examined a surgeon as a witness before Lord Denman. The surgeon answered every question put by the counsel in technical language. At the close of the examination, the counsellor observed, "My Lord. It is impossible for a medical man to make himself understood in other than technical terms." The judge laid down his pen and replied, in a way peculiarly his own, "Yes, that is so if he does not understand the rudiments of his profession."

The three observations before referred to of my own, the value of which the reader can estimate for himself, follow—

1.—Walking one day on the Thames Embankment, when a very high wind prevailed, I observed a house sparrow in the act of descending from an unusual height to the ground; when about 15 yards from the ground I could see and observe the bird closely, his wings did not move from his sides, he appeared as if borne up by the wind, and he moved downwards zig-zag, as we see forked lightning, when a little lower he opened his wings, then descended the rest of the way in a perpendicular direction, his two feet were pointed directly to the earth, and, not only pointing, but as if actually drawn down by some unseen agency, the very external points of his claws touched the ground first; when he arrived he did not hop as sparrows generally do, but ran on the ground as domestic fowls run.

2.—Sometime after, when walking in Surrey on a clear calm day in the early part of the month of November, I saw the fall of a sycamore leaf from a rather lofty tree. I observed that in its descent it fell first with one of its edges pointing towards the ground, then the other edge of the leaf; when it arrived at a distance of about 2 feet, it fell perfectly flat, the front or face of the leaf first; at the time the leaf fell, the sap in the tree on which the leaf had grown, and from which it fell, had receded from the branches of the tree into its root. This afforded, to my mind, evidence of three of the laws in the material creation, and that those three laws worked together in unison, viz.: 1. The receding of the sap, which had hitherto prevented such fall of the leaf. 2. An alteration in the equal pressure, so that the downward pressure of the atmosphere took down the leaf, and—3. The earth's attraction.

3.—Many years before the dates of either of the observations 1 and 2, being on the sands at Margate one day, a few minutes after the tide ebbed, I found the sand firm to walk on. Now the cause of that firmness I attribute to—1. Atmospheric pressure.—2. The attraction of water in the sea outside the shore, and—3. The globular form of the sand; so proving that the laws of creation are made to act together in unity.

III. Central Heat.

In an article on geology, contained in Chambers' Encyclopædia, a very useful book of reference, the theory is fairly stated to prove and account for central heat's existence in the earth; which theory appears to me to be founded upon unsupported conjecture, and is wholly opposed to well established phenomena, which may, and I believe is and has been conducive to the present method in use in ventilating coal mines, and has been a wall set up to stop the way against enquiry. In the article here referred to, it is stated, *inter alia*, as follows:

"The long entertained opinion of the existence of a central heat seems on the whole fairly established upon such facts as these: 1. There is a regular and gradual increase in the temperature of all deep mines equal to 1° F. for every 55 feet of descent after the first 100. 2. Deep wells have always a high temperature. This has been carefully determined in Artesian wells, not only by applying the thermometer to the water at the surface which has arisen from a known depth, but also by sinking the instrument to various depths. The results have shown an increment similar to that exhibited in mines. Hot or boiling natural springs rise through great and deep fissures. 3. Igneous rocks, that is to say rocks which have cooled from a state of fusion by heat, invariably come from below upwards, and thus testify to an amount of internal heat able either to retain those rocks in a state of fusion, or to convert them into a fluid condition before their ejection. 4. Physics also contributes important evidence. The specific gravity of granite or baysalt is scarcely 3°, while that of the earth, according to the recent experiments of Airey, is about $6\frac{1}{2}^\circ$. If the earth were solid, the influence of gravitation would so increase the density of the composing rock as to give a greater specific gravity for the earth than $6\frac{1}{2}^\circ$.

"There must then be some expansive force acting to reduce the gravity, and the only force with which we are acquainted which could so act is heat. On the other hand, physics raises difficulties which militate against the fluid condition of any considerable portion of the earth's interior, and in these difficulties it is supported by astronomy. If, however, the observations made in mines and wells supply a measure for estimating the increase from the surface downwards of that heat which seems to be fairly established, then it would follow that the solid crust of the earth is not more than 25 miles thick, for the heat at that depth would be so great as to fuse any known substance."

To demonstrate the absurdity of the theory of central heat, it will only be necessary to shew from principle well established that the cause of heat in wells and mines increasing with the depth arises from another cause which acts precisely in the self same way in wells and mines, namely, *Atmospheric Pressure*, that is to say, heat increases with the density and stillness of the air, and the more the air is compressed by pressure, in the absence of equal pressure, it acquires increased heat, which affords proof equal to mathematical certainty that the increase in mines and wells is caused by atmospheric pressure and the quick diurnal motion of the earth, and that the theory of central heat is altogether a fallacy.

If it can be proved that the increment of heat, according to depth, is caused by pressure, absence of equal pressure, and motion, it will add another instance to the list of fallacies erected upon the baseless foundation of conjecture, so that darkness and ignorance is the natural consequence. Dr. Noah Webster, whose dictionary of the English language is, I believe, second to none other, when explaining the word "firmament" says (quarto edition) "Firmament (furmament) *n*, *firmamentum* from *firmus firmo*. The region of the air, the sky, or heavens, in *scripture* the word denotes an expanse, a wide extent, for such is the signification of the Hebrew word coinciding with regio, region, and reach." The original does not, therefore, convey the sense of solidity, but of stretching extension: the great arch or expanse over our heads, in which are placed the atmosphere and the clouds, and in which the stars *appear* to be placed, and are actually seen.

"And God said let there be a *firmament* in the midst of the waters and let it divide the waters"—Gen. 1.—14.

If I do not greatly mistake, Dr. Webster has fallen into the same error on the word "Firmament" as he says Dr. Johnson did, and Dr. Webster's words about Johnson apply with as great, if not greater force to Dr. Webster himself, for when Dr. Johnson wrote, fewer authorities were accessible to him than Dr. Webster could refer to.

Dr. Webster says in the Introduction, quarto edition, p. lxxv, "Dr. Johnson was one of the greatest men that the English nation has ever produced; and when the exhibition of truth depended on his own gigantic powers of intellect, he seldom erred. But in the compilation of his Dictionary he manifested a great defect of research, by means of which he often fell into mistakes; and no errors are so dangerous as those of great men. The authority created by the general excellence of their works gives a sanction to their very mistakes and represses that spirit of inquiry which would investigate the truth and subvert the errors of inferior men. It seems to be owing to this cause chiefly that the most obvious mistakes of Johnson's Dictionary have remained to this day uncorrected and still to continue to disfigure the improved editions of the work recently published. In like manner the opinions of this author, when wrong, have a weight of authority that renders them extremely mischievous.

"The sentiment contained in this single line—'*Quid te exempta juvat spinis de pluribus una,*' is of this kind; that we are to make no corrections because we cannot complete the reformation—a sentiment that sets itself in direct opposition to all improvement in science, literature and morals: a sentiment which if it had been always an efficacious principle of human conduct, would have condemned not only our language, but our manners and our knowledge to everlasting rudeness. And hence whenever a proposition is made to correct the orthography of our language, it is instantly repelled with the opinion and *ipse dixit* of Johnson."

In an article in Chambers' Encyclopædia, on the word "firmament," it is stated, "a word in use of old to signify the vault of heaven. The term found its way into English from the Vulgate, which renders the Septuagint *Stereoma* and the Hebrew *Rakia*, by the Latin *Firmamentum* (Gen. 1. 6). Rakia (from the verb to beat or strike out) signifies whatever is expanded or stretched out, and it was especially employed by the Hebrews to denote the hemisphere above the earth, compared (Exodus 24. 10) to a splendid and pellucid sapphire. Elsewhere (Ez. 1. 22. 26) it is spoken of as the "floor" on which the throne of the Most High is placed. Hence it follows that the notions of solidity and expansion were both contained in the Hebrew conception of the firmament."

Ainsworth construes and expounds the word "Firmus" 1. Firm, steady, constant, valid, compact, substantial, sure, strong, lusty, bold, hearty, able. 2. Hard, solid. 3. To be depended upon. 4. Nourishing, strengthening.

A most useful rule or canon of construction is mentioned in a case not long ago decided by one of our judges, V. C. Bacon, 6 Law Reports, Chancery Division, p. 138. The judge said: "Now no doubt the mere letter of the will or any other instrument is not to be adhered to if a contrary signification can be suggested by the context of the instrument. *The spirit is to prevail and the letter is not to be allowed to kill; that I take to be a plain clear canon of construction.*"

If we read Gen. 1., 6—10, by or according to that rule, we shall see and understand the exact meaning of the word "firmament" as there used and intended, and that such meaning is in accordance with the now known properties of atmospheric fluid.

Gen. 1., 6—10—"And God said let there be a firmament in the midst of the waters, and let it divide the waters from the waters; and God made the firmament and divided the waters which were under the firmament from the waters which were above the firmament, and it was so. And God called the firmament heaven, and the evening and the morning were the second day. And God said let the waters under the heaven be gathered together into one place, and let the dry land appear; and it was so. And God called the dry land earth, and the gathering together of the waters called He seas; and God saw that it was good."

The following paraphrase is not only in exact accordance, and expresses the true and exact meaning of the words of 1 Gen., 6—10, but is a true and precise statement of the law which affects that part of the material creation in which we now live.

Paraphrase.

And God said let there be atmospheric fluid in the midst of the waters, to divide the waters from the waters by keeping the waters in a liquid state. And God made the atmospheric fluid and separated the waters which were under the pressure of the atmospheric fluid from the waters which were above such weight; and God called the atmospheric fluid heaven, for it has other and heavenly work to do. And God said let the waters under the pressure be gathered together into one place, and channels appointed to receive them, and let the dry land appear; and it was so; and God called the dry land earth; and the gathering together of the waters called He seas; and God saw that it was good.

The reader will, I think, agree with me that Dr. Noah Webster has omitted from his otherwise excellent exposition of the word, the primary signification, *firmness and solidity.*

Sir George Jessel, Master of the Rolls 1873—1883, originated two rules or canons of construction applicable and of the utmost significance:

1. "*Every word that has more than one meaning has a primary meaning, and if it has a primary meaning, you want a context to find another.*"—Law Reports, Chancery Division, vol. 3, p. 672.

2. "*You may control the plainest words by a reference to the context, but then it has been said very often you must have a context even more plain, or at least as plain, it comes to the same thing as the words to be controlled.*"—Law Reports Chancery Division, p. 592.

We have seen that the primary meaning of the word "firmament" is to hold firm, but the same word has other meanings—the conductor of light is one of them. This is well stated by James Ferguson, "Astronomy," s. 177-178: "According to Dr. Keill (see his 'Astronomy,' p. 232), and other astronomical writers, it is entirely owing to the atmosphere that the heavens appear bright in the day time. For, without an atmosphere, only that part of the heavens would shine in which the sun was placed; and, if we could live without air, and should turn our backs towards the sun, the whole heavens would appear as dark as in the night, and the stars would be seen as clear as in the nocturnal sky. In this case, we should have no twilight, but a sudden transition from the brightest sunshine to the blackest darkness immediately after sunset, and from the blackest darkness to the brightest sunshine at sun-rising, which would be extremely inconvenient, if not blinding, to all mortals. But by means of the atmosphere, we enjoy the sun's light reflected from the aerial particles, for some time before he rises and after he sets. For, when the earth by its rotation has withdrawn our sight from the sun, the atmosphere, being still higher than we, has the sun's light imparted to it, which gradually decreases until he has got 18 degrees below the horizon, and then all that part of the atmosphere which is above *us is* dark. From the length of twilight the Doctor has calculated the height of the atmosphere (so far as it is dense enough to reflect any light) to be about 44 miles, but it is seldom dense enough at two miles height to bear up the clouds."

s. 178. "The atmosphere refracts the sun's rays, so as to bring him in sight every clear day before he rises in the horizon, and to keep him in view for some minutes after he is really set below it. For, at some times in the year, we see the sun ten minutes longer above the horizon than he would be if there were no refractions, and about six minutes every day at a mean rate."

The "firmament" (atmospheric fluid) is also the conductor of sound—without its agency the song of the skylark, the voices sometimes inexpressibly welcome to our ears, the memory of words and the tone of voice of a speaker, no more to be heard in this world, could not and would have never been heard. The strains of music operating with soothing influence on the spirit, after the wearisome experiences and the disappointments of the world, could not so operate because they could not be heard.—This is most important when we come to consider the difficulty of speaking and hearing in mines, underground railways, and ill-ventilated rooms. No sound could enter our ears but for the property of the atmosphere now under consideration. This was clearly demonstrated to me not very long ago, while seated in an omnibus standing ready to start on its journey. I was seated on the right side entering the vehicle, a lady was seated opposite; a gentleman came up to the window and spoke to the lady; he was not more than 3 feet from the glass, which was of a thin substance. From the appearance of the gentleman's face it was evident he spoke with effort and in a loud tone of voice; the lady indicated to the speaker that he was not heard. The gentleman then came round to the rear of the omnibus and spoke to the lady in a low tone of voice. When the gentleman had departed, I enquired of the lady if she heard anything that was said to her while the gentleman was speaking from the side, the lady answered, "not a word," but that when addressed from the rear of the carriage she had heard "every word." I have said the glass was of a thin substance, but it had the same effect in preventing sound to proceed as if it were 100-fold its thickness; thus proving beyond all doubt that sound is carried by the air. That it moves in straight lines is equally clear, for if a speaker directs his speech in a straight line with the ear of the one addressed, the one spoken to will hear more distinctly than if the speaker was looking at a paper or book while he spoke, or if he spoke with his face turned away from the one addressed;

and another thing is observable, that if the room be charged with rarified air, sound is impeded. Rarified air being weaker, does not carry sound as it is borne by fresh air, that being so, then the remedy is, obviously, to get rid of the rarified air, which, of course, may be effected by providing an outlet for it to escape.

IV. Elasticity of the Atmosphere and its property to rush from under pressure into freedom.

It is on this principle that a balloon which contains a lighter fluid rises in the air.

Chimnies quicken the ascent of hot and therefore rarified air by keeping a long column of it together. A column of two feet high rises or is pressed up with twice as much force as a column of one foot, and so in proportion for all other lengths; just as two or more corks strung together and immersed in water tend upwards with proportionately more force than a single cork; or as a long spear of light wood allowed to ascend perpendicularly from a great depth in water acquires a velocity which makes it dart above the surface, while a short piece under the same circumstances rises very slowly. In a chimney where one foot in height of a column of hot air is one ounce lighter than the same bulk of the external cold air, if the chimney be one hundred feet high, the air or smoke in it is propelled upwards with a force of one hundred ounces. In all cases, therefore, the *draught* of a chimney is proportioned to its length. It follows, then, if a pipe or tube were suspended to and along the roof of a coal mine, or an underground railway, the rarified air would rush into it, and would be drawn off on the same principle of attraction; and the longer the tube the stronger the draught. The common household bellows illustrates this. The valve under the bellows is wider than the end of the bellows spout. As soon as the bellows is filled with air, which enters into it by the valve, and the person who is using the bellows presses the upper and lower boards of the bellows together by the two handles, the air rushes out at the spout of the bellows; but if the spout were as wide as the valve, then the atmospheric pressure being equal, the confined air would not come out at the spout. It is on this principle that the confined or rarified air is kept in mines and underground railways. The descending or down cast shaft of the mine, and the ventilating or up cast shaft being of the same dimensions, the downward pressure consequently being equal, fastens the stagnant or rarified air at the bottom of the mine. The blowholes made in various places along underground railways have the same effect.

V. Heat diffuses itself amongst neighbouring bodies until all arrive at the same degree of temperature. Under this proposition I attempt to account for the formation of ice.

In the northern and temperate regions, and even in the tropics, when the air above the water is impregnated with frost, the air so impregnated being colder than the air in the water, the air in the water diffuses itself amongst the particles of air above the water and congealment is the consequence. The congealed substance we call ice, which is thicker or thinner according to the intensity and duration of the cold in the air above the water. Ice thickens from beneath, according to the continuance of the frost above the water, shewing the accuracy of the conclusion arrived at by the learned Dr. Arnott, where he says that the air ascending a chimney is held together by the law of attraction (adhesion is a better word). Ice is not a normal natural substance, but caused by one of the parts of water, *atmospheric fluid*, leaving it, and the air passing from the water being held together by adhesion, the air under the ice is drawn up through the ice into the air above it. And this conclusion is further proved to be true from this circumstance, viz.:—when what is called a thaw sets in, the ice begins to melt and returns into its normal liquid state, and the ice melts first on the surface which is plainly owing to the air above the ice becoming warmer than the ice and diffusing itself into the colder ice. In some cases water becomes so hard that the air outside of it cannot re-enter into it.

About the middle of the seventeenth century, William Greenhill, Vicar of Stepney, wrote a book entitled "An exposition of the Five first chapters of the Prophet Ezekiel, with useful observations thereupon," published—second edition 1650. He says, (page 165) when writing upon Ezekiel 1., 22., "And the likeness of the firmament upon the heads of the living creature, was as the colour of the terrible Crystal stretched forth over their heads above." (page 166) "The colour and likeness of it was as the terrible crystal—we must a little explain these words—it was the likeness of the firmament itself; the Heb. words run thus, the ice, the terrible, or the terrible ice, water hardened by cold, whence crystal hath its birth; for though ice be not crystal, yet crystal is from ice; when ice is hardened into the nature of a stone it becomes crystal; more degrees of coldness, hardness and clearness, give ice the denomination of crystal, and the name crystal imports so much, that is water contracted into ice, and Pliny saith, the birth of it is from ice, vehemently frozen, and so you see the original of crystal."

A further illustration of the doctrine that heat diffuses itself among neighbouring bodies until all arrive at the same degree of temperature, and a conclusive proof of it is found in the fact that the arctic bear, if deprived of his fur coat, and then turned out into the cold air of Greenland, would soon die. A few hours would deprive him of life, for the animal heat in his body would diffuse itself amongst the cold particles of air outside his body. His fur coat is given to him to prevent that diffusion. If we make a way for rarified air to rush out from under pressure, we shall arrive at the wished for end, viz.:—the prevention of coal mine explosions; and, on the same principle, to obtain thorough ventilation in underground railways, in public rooms, and in other places requiring ventilation. I consider that the laws governing the firmament have not been understood, or if understood, disobeyed, which cannot be done with impunity, for it has led to the consequence of coal-pit explosions and all the other ills and inconveniences arising from impure air and the absence of ventilation. I state this as a reason for my having to request that my readers will have patience to hear the whole case, and the witnesses brought forward to prove it.

Dr. Arnott says, vol. 2, p. 17, "A method was adopted by Count Rumford to ascertain the relative degrees in which furs, feathers, and other materials used for clothing, conduct heat, or, which is the same thing, resist its passage; and after stating the experiments of the Count, he gives the following table to shew what known substance best resists the diffusion of heat:—

“These experiments have shewn, as a general rule, that density in a body favors the passage of heat through it. The best conductors are the metals, and then follow in succession diamond, glass, stones, earths, woods, &c., as here noted:

Metals—silver, copper, gold, iron, lead.	
Diamond.	
Glass.	
Hard Stones.	
Porous Earths.	
Woods.	
Fats, or thick Oils.	
Snow.	
Air	576
Sewing Silk	917
Wood Ashes	927
Charcoal	937
Fine Lint	1,032
Cotton	1,046
Lamp Black	1,117
Wool	1,118
Raw Silk	1,284
Beavers’ Fur	1,296
Eider Down	1,305
Hares’ Fur	1,315

"Air appears near the middle of the preceding list, but if its particles are not allowed to move about among themselves, so as to *carry* heat from one part to another, it *conducts*—in the manner of solids—so slowly, that Count Rumford doubted whether it conducted at all. It is, probably, the worst conductor known, that is, the substance which when at rest impedes the passage of heat the most. To this fact seems to be owing, in a considerable degree, the remarkable non-conducting quality of porous or spongy substances—as feathers, loose and filamentous matter, powders, &c., which have much air in their structure, and often adherent with a force of attraction which immersion in water, or even being placed in the vacuum of an air pump, is insufficient to overcome.

" While contemplating the facts recorded in the above table, one cannot but reflect how admirably adapted to their purposes the substances are which " (the Creator) " nature has provided as clothing for the inferior animals, and which man afterwards accommodates with such curious art to his peculiar wants. These animals require to be protected against the chills of night and the blighting blasts of winter; and some of them which dwell among eternal ice, could not have lived at all but for a garment which might shut up within them nearly all the heat which their vital functions produced."

Any further citation from the learned Dr. Arnott's book might lessen the effect of the argument.

It is of the utmost importance to act upon the law of diffusion of heat in the ventilation of coal mines, for if we can give the heat in coal mines a free passage into the air outside the mine, we shall render the temperature at the bottom of the mine, irrespective of depth, very little higher than the temperature in the cabin at the mouth of the descending shaft.

I have attempted to shew the law of the visible creation in the second, third, and fourth propositions—Atmospheric Pressure, Central Heat, and Elasticity of the Atmosphere. As it is of vital importance in this inquiry to settle the question of central heat, I have made the attempt to shew that all the reasons which are adduced to prove its existence fail, and, on the ground that such existence can be accounted for by the operation of the known law of atmospheric pressure, and the absence of equal pressure in mines and wells, we may safely consider it to be a groundless supposition.

I would ask leave to add some further remarks upon part of my subject.

It is a well settled principle in physics that when two combustible bodies are rubbed briskly together in a dry state for a certain time, fire is produced; thus we read of savages obtaining fire by rubbing dry sticks together. And we know that the axle around which the wheel of a locomotive engine revolves must be lubricated constantly with oil or fatty substance, or ignition (fire) is the consequence. Now the atmospheric pressure, fifteen pounds on every square inch of the earth's surface increasing with the depth of a mine, the weight at the bottom is increased by the absence of the like amount of equal pressure; and taking the diurnal motion of the earth—which never for a moment stops—into consideration, we may safely conclude that temperature is increased by that motion, and not by central heat.

The speed of the earth's diurnal motion is thus stated by Ferguson, in the latter part of the 47th section; after stating the speed of the earth's annual motion as being at the rate of 58 thousand miles every hour, which motion, though 120 times swifter than of a cannon ball, is little more than half as swift as Mercury's motion in his orbit, continues: "the earth's diameter is 7,970 miles, and by turning round its axis every 24 hours from west to east, it causes an apparent diurnal motion of all the heavenly bodies from west to east. By this rapid motion of the earth on its axis, the inhabitants on the equator are carried 1,042 miles every hour, whilst those of the parallel of London are carried only about 580."

A cannon ball flies at the rate of 480 miles an hour (idem section 9).

RECAPITULATION.

When writing upon such a subject as the one before us, it is of all importance to write so as to be understood.

The law of the "*Firmament.*" Perfect in every part, and one law or property made to act in its own perfect order—without confusion and without mistake. And as the knowledge of that law is indispensable to bringing the powers of each part or property of such law into practice where necessary, the reader must keep in mind the five before stated Propositions or Divisions:—

I.—Lighting and Ventilating Mines now in use, and demonstrating, or shewing, that such way of ventilation is a direct infraction of the laws of the firmament,* and hinders, or rather prevents ventilation.

*** By the word "*Firmament*" I mean atmospheric fluid, or the air we breathe.**

II.—*Atmospheric* Pressure.—Which is now known to be about fifteen pounds weight on every square inch of the earth's surface. But as there is equal pressure all round, we do not feel the weight. When we are in confined places, such as mines, close rooms, &c., the pressure is not quite so equal, and we are, in consequence, made to feel uneasy.

III.—Central Heat.—The cause of the error so long persisted in as regards ventilation of coal mines, *i.e.*, heat is supposed to rise from below; while on the contrary, it descends from above—as is shown by the fact, that the degree of heat is according to depth.

IV.—Elasticity of the Atmosphere, and its Property to Rush from under Pressure into Freedom.—When air becomes heated, it is made thinner and to occupy more room than it did before it became so heated, and the longer the heated air is confined the thinner and hotter it becomes. It sounds to reason, therefore, that if the property of such thinned or rarified air be to rush out into the open air, we have only to make a passage (which should be air tight) for its journey out of confinement into freedom, in order to ensure the desired ventilation; and I propose such a way by constructing and suspending pipes or tubes along the roofs of the "ways" which are cut out underground to get at the coal.

An important property or law of the atmospheric fluid must be carefully borne in mind, that is, that it adheres or sticks together, so that if there be a way for the thinner air to leave the mine, it will enter into that way and draw all the remaining thin air in the mine along with it, so that the pipe or tube need not reach very far down the "ways."

V.—Heat diffuses itself amongst neighbouring bodies until all arrive at the same degree of temperature.—Under this head I have attempted to describe how ice becomes ice. If I am correct as to the formation of ice, it cannot for a moment be doubted that the property, or law of adhesion, is inherent in rarified air; that is, air made thinner by heat.

If we succeed in ventilating mines, I think of suggesting a movable railway to be laid down on the mine floor, from the coal to the bottom of the descending shaft.

But if we can make "Peat" as good for fuel as coal, our fellow men may earn for themselves and their families food and raiment in open day and daylight.

The fact of my having resided in the immediate vicinity of coal mines in the north of England for many years in the earlier part of my life, and having had dear friends engaged in coal mining, both as employers and workmen, may be the cause of my entertaining a rooted interest in coal mine operations. I have read and studied physics nearly the whole of my life. I began to apply my mind to the subject of ventilating mines in 1870, and having continued in the study of the subject, I now wish to draw the reader's attention to the following division.

VI.—The method suggested to reduce the temperature in mines, and to obtain circulation of air or atmospheric fluid throughout all the workings therein, and which method will apply to ventilation generally.

Perhaps the best mode of introducing the experiment—"Suggestions of a Method to obtain Ventilation throughout Coal Mines"—will be to try the effect of preventing smoky chimneys, by constructing a fire place on Richard Noble's brass furnace principle, then ventilation of public rooms, and then tunnels and underground railways, and afterwards of coal mines, so proceeding from the less to the greater by way of induction, the appropriateness of this word will be evident if we refer to Dr. Noah Webster's Dictionary of the English Language, extract:

" INDUCTION. n. [Fr., from *inductio*, see induct.]

"1. *Literally* a bringing in, introduction, entrance. Hence,

"2. The bringing forward of particulars, or individual cases, with a view to establish some general conclusion.

3. "A kind of argument which infers respecting a whole class what has been ascertained respecting one or more individuals of the same class."—*Whately.*

"This is the *inductive method* of Bacon, and is the direct reverse of logical *deduction.* It ascends from the parts to the whole, and forms from the general analogy of nature, or general presumption in the case, conclusions which have greater or less degrees of force, and which may be weakened or strengthened by subsequent experience. It relates to actual existences, as in physical science, or the concerns of life. Deduction descends from the whole to some included part; its inferences are necessary conclusions according to the laws of thought, being merely the mental recognition of some particular, as included or contained in something general." The rest of Dr. Webster's explanation of the word induction relates to another science, Metaphysics. If the least expensive thing succeeds, it would be encouraging in going *to* the next above it.

The two laws, atmospheric pressure forcing atmospheric fluid into all available openings, it becomes rarified by heat and fills more space than it occupied before, that when it has become so rarified it has the property to rush out from under pressure into the open air where there is less pressure. Pressure of the atmosphere being greatest the nearer to the earth, rarified air always rises above fresh air. All these properties will be found to act with the same effect as they did in the case of the brass furnace constructed by Richard Noble, and described ante p. 11. If this system was tried, which might be done at little expense, it would give encouragement to proceed further. I have been informed that in the rooms in the Law Courts in the Strand, wherein the judges sit to administer justice, when the Courts are held and are crowded with counsel, solicitors, suitors, witnesses, in some the jury in addition, and in all cases by the public, there is experienced a difficulty in hearing and breathing; this is occasioned by the air becoming rarified by the breath of so many individuals being present; this assertion could be easily tested, in a more or less confined space, when only a very few were in the Court. A counsel, or other person, speaking to the judge from the same spot as he would speak if the Court were crowded, would be found to be heard plainer, and the few could breathe more freely than they would in the same Court Room when crowded; the reason for this is that the more often air is breathed, the more of it is required for the next breath. It must be carefully borne in mind, that in case any person be in the crowded Court, having any—even incipient—infectious disease upon him, the breath of such an one contaminates the air in the Court, and renders free circulation desirable. And as to hearing, rarified air does not conduct sound like fresh air, it being weakened by expansion. An opening in the ceiling of the room should be made, and a tube of sheet iron or tin inserted, made wide at the opening and tapered, carried up out of the roof, and as near the inside of the outside wall as may be; the apex of the tube must be made to taper on the principle of the spout of the household bellows. Fresh air would then enter without any artificial force.

When you ask to have "fire-damp" defined, people tell you with all seriousness that it is when gas is let out of fissures in a mine and coming in contact with the bodies of the miners, the miners' bodies become so damp as to make you think they had been immersed in water. Now the gas so liberated had been confined for centuries, and so imprisoned as not to have any possibility of escaping, and heat of that air increasing with the length of time it is so imprisoned, that it becomes impregnated with the inflammable properties of coal, as gas is generated, the heat produced by it in the mine when liberated coming in contact with the bodies of the miners (who work in the mines naked, or nearly so) it enters the bodies of them, and draws through the pores of their skins all the moisture in their bodies. Sometimes "fire-damp" is called "choke-damp," meaning that the poor miners are choked, which is correct, but the additional word "damp" is improper, for it seems to impart that the gas is damp. The use of these vulgar and unscientific words are, generally, a hindrance to the acquisition of knowledge in any science.

The underground railways next claim attention. If a tube or pipe, such as are laid down from any gas works to supply the gas required to light the streets, and other places in towns, were suspended from the roof of the tunnel for, say, half a mile in length, made on the same principle as that recommended for mines, travellers along such lines would not feel that amount of difficulty in speaking, hearing, and breathing which now oppress them and which cause a feeling of relief when the train emerges into the open air. The doctrine of atmospheric pressure is too well established to be either denied or doubted. Then what are we to think of the knowledge of the man who constructed blow-holes, in the absence of pipes or tubes, as a way to ventilate underground railways? The blow-holes admit fresh air into the tunnel, and that fresh air so admitted effectually prevents the rarified air escaping. They may be of use where there is a tube, but I greatly doubt it. If a tube or pipe were suspended between the Cannon Street Station and Westminster, and the blow-holes were closed, the pipe or suspended tube carried up from the Westminster Station end of the suspended tube on the ground for 300 yards, then carried up 50 feet as a chimney, the circulation of air in the tunnel would be very sensibly felt.

The tubes or pipes must in the manufacture and fixing be entrusted to workmen whose business it is to lay down the pipes now in use, in carrying gas from the gas works in towns to the various places where it is required, as from their daily employment they get much experience of the nature of gas.

Any one travelling by underground railways occasionally, may not feel that it has a weakening effect upon the respiratory organs, but if the travelling be daily, it will be found, in time, that those organs have become impaired.

The sewers under large towns and populous districts are constructed to carry away the refuse matter. Some of these sewers extend for miles. The longer such sewers extend the higher the temperature becomes, and inflammable gases are generated by their contents in a greater or less degree, according to their length. If a metal tube were suspended from the roof of the sewer at a distance of 500 yards from one end, and carried to the end opposite, the gases would be carried off with a force according to the length of the sewer, they could then be collected into a gasometer and used in the same way as coal gas. Burning would be the best way of disposing of the sewer gas—if it could be disposed of in that way safely; the rest of the contents of the sewer would then be rendered comparatively inocuous.

To return to the subject of mines. What is meant by down cast and up cast shaft is as follows: Down cast, the *descending;* and Up cast, the ascending, or ventilating shaft. My contention is that when these two are made of the same or nearly of the same width, the atmospheric fluid descends down both shafts equally, and in consequence holds the rarified air fast at the bottom of the pit. We have seen that air to be removed must not be impeded, but left to follow its natural tendency, that is, to rush out from under pressure into freedom, which can only be done by the ascending or ventilating shaft being closed; and if a pipe or tube, about 18 inches diameter, be suspended from the roof of the mine, for say

300 yards down the "way," if the "way" is say a mile long, the tube should be 3 feet in diameter at the mouth farthest away from the bottom of the ventilating shaft, and made 18 inches diameter, at 12 feet from the mouth, gradually tapering, then carried up to the top of the ventilating shaft and thence along the ground either open, or to protect the tube in a drain—for, say, 300 yards; at the end of this it should be carried up chimney fashion for 50 feet; the rarified air in the mine would rush into the tube, and the adherence of the particles of the rarified air would draw all other rarified air in the mine after it. The deeper the mine the more rarified the air becomes, and the longer the tubes or pipes the stronger the draught. If this method be put in practice, the poor men employed in coal mines would be able to keep clothed when at work, and not, as at present, to work naked. No wonder at "the squalid hue of their skins, their sunken eyes, and their languid movements," for on leaving work they do not take sufficient care to protect themselves against the dangerous effects of coming out of Indian heat into what to them must be semi-Arctic cold. It is a common saying with them, or at least was thirty years ago. "O, it is nothing when you are used to it." But whether they feel it at the time or not, we may be sure that they do after the lapse of a very few years.

It would require the pen of a Washington Irving to describe the effect of a coal-pit explosion. Imagine a man running from the pit's mouth, or bank, into the village, crying "*Fire Damp.*" The poor wives, aged parents and the children, know, but too well, its meaning. The poor heart stricken wives and children, running in wild distraction in the direction of the coal-pit, the aged supported, it may be, on their way by some pitying arm, and on arrival, to see them waiting in indescribable agony for the arrival of the carriage—containing occupants alive, dying, and dead. Then to hear the mingled cry of joy and grief, is altogether beyond my power to describe.

The cry of joy sent up by the owners of the living, and the qualified cry of joy of those whose own appear to have life in them, fostered by the hope that they may with care recover. But when joined with the wail, sent forth by the proprietors of the dead, produces a feeling distressing in the extreme, and that cry is heard afar off in more senses than one. What, then, must the feeling be of those whose earthly all is gone—home, and all its endearments at once obliterated, and they are as the sheep mentioned by the poet Virgil, "left to graze on the bare flint stones."

Pursuing the primary object of my task, I have said I have no faith in the DOGMA of the geologists regarding the existence of central heat. I have still less faith, if possible, in the "guess" (altogether founded on unsupported conjecture) they have made about the origin of coal. In that useful work, "Chambers' Encyclopædia," article Coal, it is said: "Several theories as to the mode of the origin of coal have been put forth from time to time. The one now generally believed in, is that the rank and luxuriant vegetation which prevailed during the carboniferous age," (whatever age that may mean) "grew and decayed upon land but slightly raised from the sea; that by slow subsidence this thick layer of vegetable matter sunk below the water, and became gradually covered with sand, mud, and other mineral sediment; that then, by some slight upheaval of the sea bottom, or other process, a land surface was once more formed, and covered with a dense mass of plants, which, in course of time, decayed, sank, and became overlaid with silt and sand as before. At length, thick stratified matter would accumulate, producing great pressure, and this acting along with chemical changes, would gradually mineralise the vegetable layers into coal." Some experiments made by Dr. Lindley, a few years ago, shewed that of a large number of plants kept immersed in water for two years, the ferns, lycopodiums, and pines, were those which had the greatest powers of resisting decay—and coal seems to be mainly composed of the substance of the ancient representatives of these three orders of plants. The interesting fact has also lately been proved by Huxley, Morris, Carruthers and others, that in many instances the bituminous matter in coal, is almost wholly formed of the spore cases and spores of plants allied to our club mosses and ferns.

Whatever may be true in the experiments of Dr. Lindley, Huxley, Morris, Carruthers, and others, cannot for one hour justify the conjecture about the luxuriant vegetation which prevailed during the carboniferous age, nor be admitted into the mind of any one who is acquainted with the true origin. How that has escaped the comprehensive understanding of Dr. Arnott, I cannot tell, but it has.

The author of "Conversations on the History of England, illustrative of the events, institutions, manners, and literature, from the earliest ages to the Accession of the House of Tudor; being the second edition of the 'Vestigia Anglicana,'" when speaking of Simon de Montfort, Earl of Leicester, says of him, vol 1, p. 405, "Simon de Montfort, Earl of Leicester, a remarkable person, to whose fortunate innovations the English enjoy, at the distance of five centuries, the advantage of a representative government." And again, on pages 414—415, "But although Leicester was not a native of England, yet, inheriting a vast estate from his mother, an English woman, he was not like the strangers so much complained of, a burden to the nation. To his policy it undoubtedly owes the greatest advantage which it ever received from a single individual, the introduction to parliament of a representative body of the people. Some historians have endeavoured to deprive Leicester of this renown, by representing his experiment as only a slight anticipation of what must necessarily have happened from the increasing importance of the Commons: but had not his penetrating view brought the system into existence, it might have slept for centuries." * * * "*In how many inventions have we not observed previous projectors to arrive within the very verge of discovery, and then unaccountably turn aside from the direct road, leaving the object in its original obscurity.*"

I have set this out preparatory to speaking about an inventor who, in one of those *objects*, "turned aside, leaving it in its original obscurity," and, if the inventor had known the true origin of coal, and how it acquired its brittleness and durability as an article of fuel, he would have gone on his way, and I believe he might have made coal mines and their dangers a memory of *the past.*

In Maunder's "Scientific and Literary Treasury," there is an article, "PEAT; a congeries of vegetable matter, in which the remains of organization are more or less visible; consisting of trunks of trees, of leaves, fruits, stringy fibres, and the remains of aequatic mosses. It occurs in extensive beds, called *peat-mosses*, occupying the surface of the soil, or covered to the depth of a few feet with sand, gravel, &c. It is the common fuel of large districts of Wales and Scotland, and of some parts of England where coals are very dear. Lord Willoughby de Eresby has lately perfected a peat-compressing machine, first produced by him in 1837. In some experiments which took place at the manufactory of Mr. Napier, the engineer, specimens of peat that had been pressed two days previously were shewn to be perfectly dry, heavy. and consistent; and some that had been pressed for a year were scarcely to be distinguished from coal. As fuel for the manufacture of the finest cutlery, this peat is superior to coal, probably from its being without sulphur. It can always be obtained by the lowly population of a large portion of the British Empire with infinitely less cost of labor and time than the mere cutting and drying of turf or peat. It may also be advantageously employed in lime-burning, and in fires or furnaces, working machinery, or raising of steam."

It appears by this statement that it requires to be pressed for a year to become hard and undistinguishable from coal. If Lord Willoughby de Eresby had known how coal was originally formed, how it became hard, brittle and sulphurated, he would have been able to produce compressed peat, hard and brittle as coal, and in every respect equal, and in one respect superior, viz.: absence of sulphur. Besides all this, an important question arises as regards the residuum or ashes, for if the prepared peat were burnt in a fire grate constructed on the principle of Richard Noble's brass furnace, which would consume the whole of the peat properly prepared except a small residuum of ashes, which might be used as manure. The use of manure is to pulverize the ground where it is placed, and vegetable ashes have that effect.

The peat properly compressed and prepared might be done effectually in less than six weeks.

CONCLUSION.

My readers may perhaps complain of the many quotations I have made. My object in doing so was to lay before them the premises from which my conclusions are drawn, so that they may form some notion whether I am *justified in* such conclusions. I do not pretend to have discovered any new property in air. The suggestions about the true meaning of "And God said let there be a firmament in the midst of the waters, and let it divide the waters from the waters," Gen. I. 6—10, and the cause of the formation of ice, are original; all the rest is an attempt to apply to ventilation what learned authors have written concerning it. I have only to add to my readers, in concluding, that I have had this problem on hand, viz., that of ventilation, for the last fifteen years. During that period I have been often hindered in my researches in many and various ways. One of my difficulties arose from the same cause as that which the well-known translator of the "Koran" (commonly called the "Alcoran of Mohammed") so characteristically asks his readers' indulgence for, in an address to the reader; at the close of the last paragraph, he says: "I likewise flatter myself that they" (*i.e.*, those who were able to detect his errors and knew the difficulty of the undertaking) "and all considerate persons, will excuse the delay which has happened, when they are informed that it was carried on at leisure times only, and amidst the necessary avocations of a troublesome profession." My readers, perhaps, will not require to be informed that the author I refer to was George Sale Gent, a London solicitor. I can heartily sympathise with him, for my own very imperfect, yet deeply cherished work, has been carried on at leisure times only, and amidst the necessary avocations of the same troublesome profession.

If my inferences are well considered, and my suggestions put on trial by my countrymen, it will be to me a great gratification: and if successful, as I feel certain they must be, I shall rejoice heartily, and be thankful to Almighty God if my labor of love accomplishes the one object most dear to me—that of rendering a service to mankind.

FINIS.